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King et al.

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(54) **SMART LOCK**

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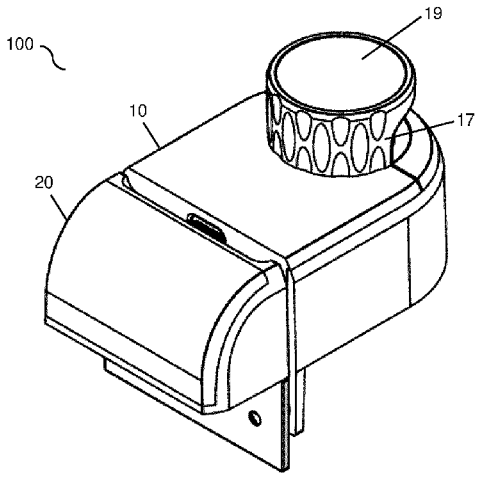
(57) **ABSTRACT**

A smart lock for securing a door comprising: a housing mountable to the door; an actuator within the housing configured to actuate a lock mechanism between a locked position and an unlocked position, the lock mechanism including a latch bolt with an angled front face, the latch bolt configured to be retractable against a biasing force provided by a biasing means such that the door is closeable when the lock mechanism is in the locked position; and a receiver within the housing configured to wirelessly receive a signal to control operation of the actuator; a sensor mountable exclusively to the door so as to generate a signal indicative of the door beginning to move; a controller arranged to receive the signal indicative of the door beginning to move,
(Continued)



the controller configured to control the actuator to actuate the lock mechanism in response to the signal indicative of the door beginning to move.

17 Claims, 8 Drawing Sheets

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E05B 55/00 (2006.01)
G07C 9/00 (2020.01)

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(58) **Field of Classification Search**
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USPC 70/275
See application file for complete search history.

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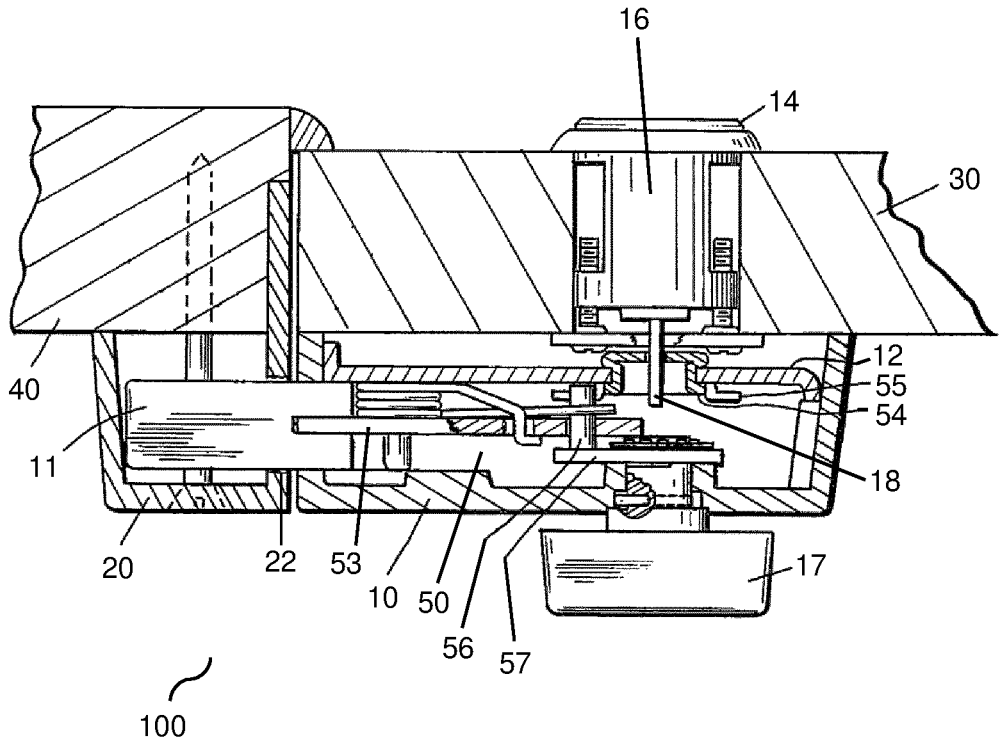
FIG. 1



PRIOR ART

FIG. 2

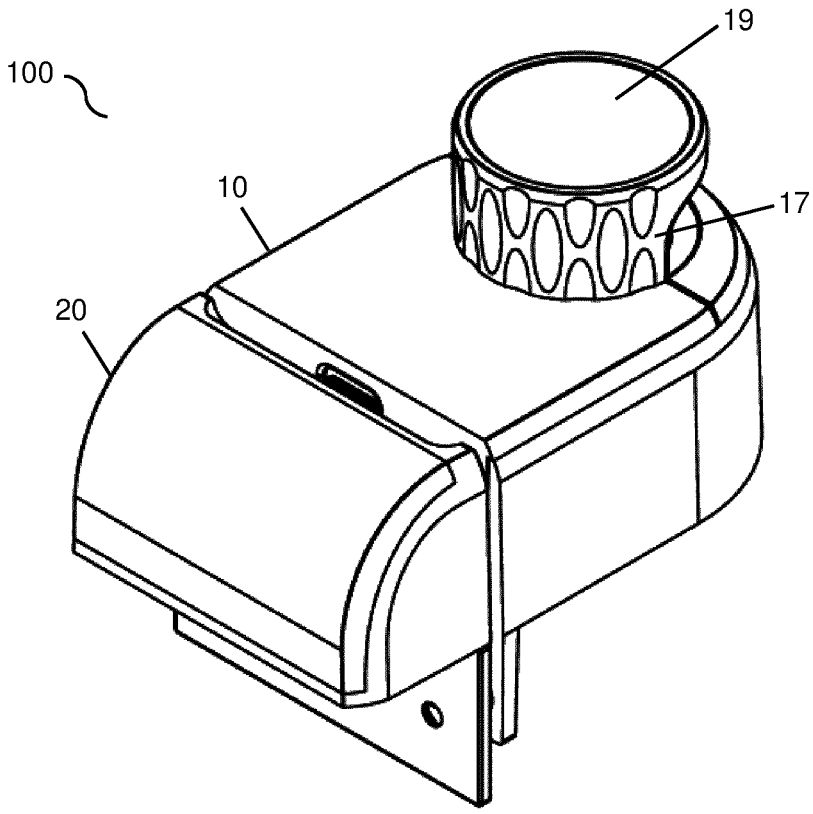


FIG. 3

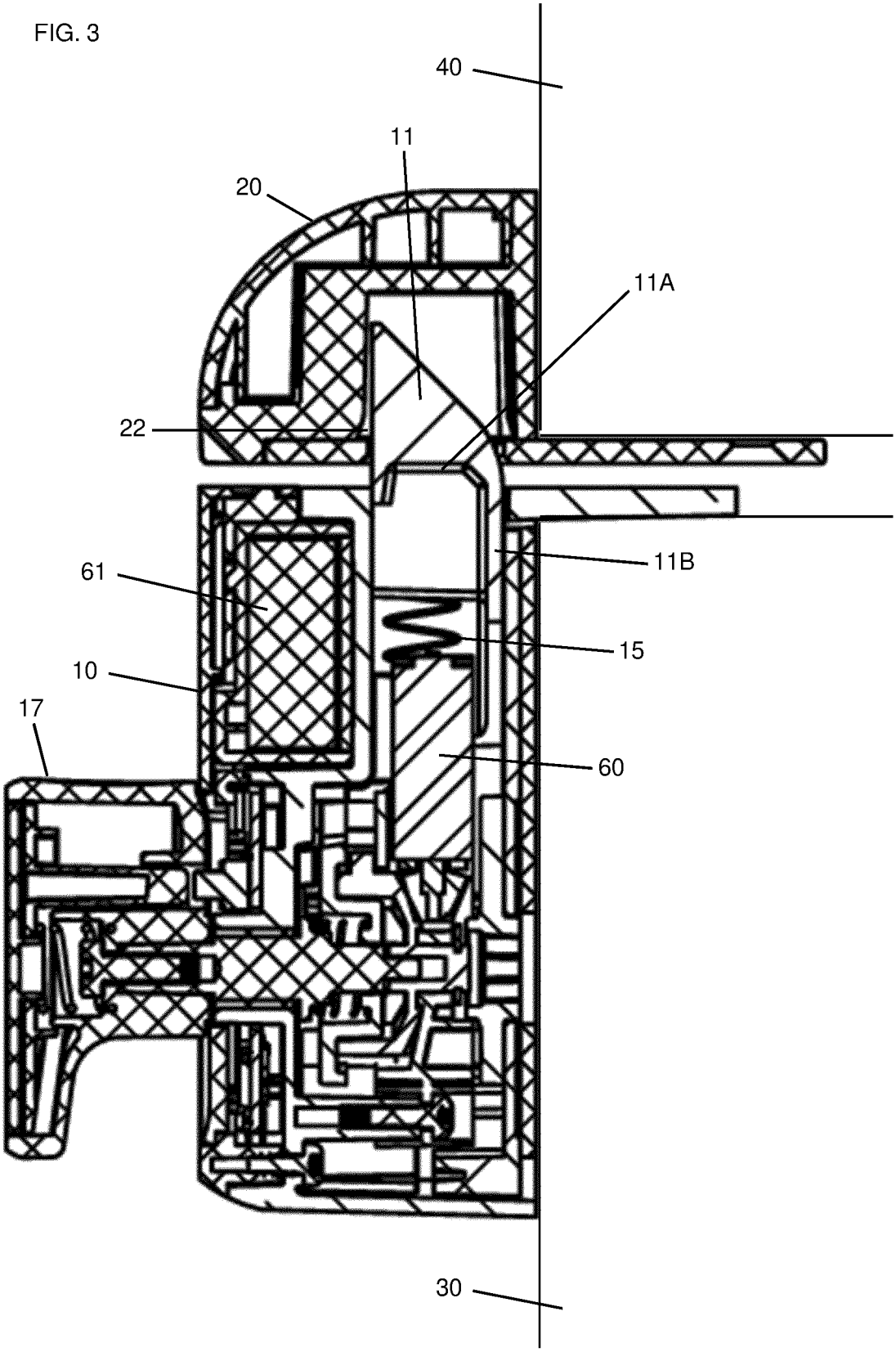


FIG. 4

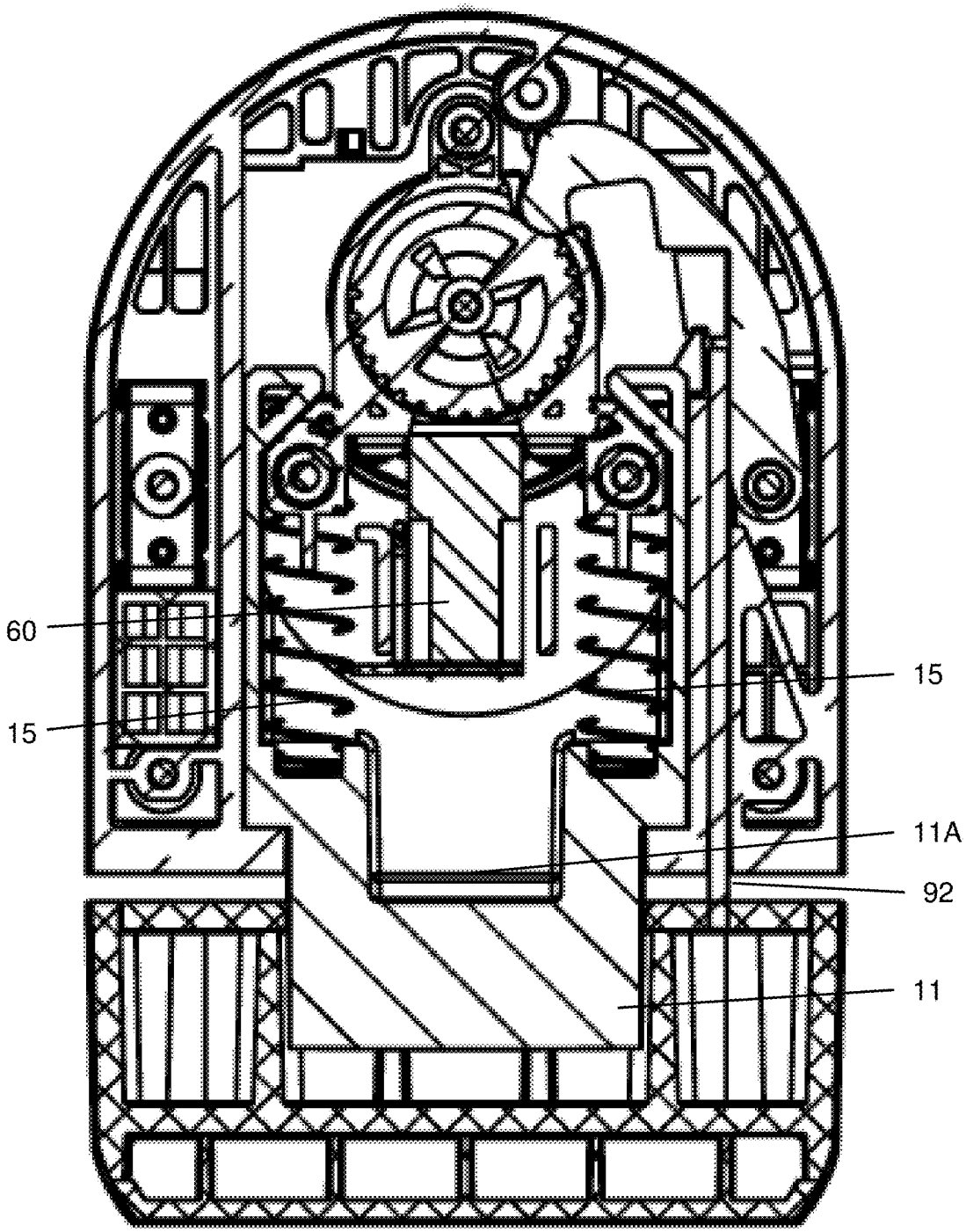


FIG. 5A

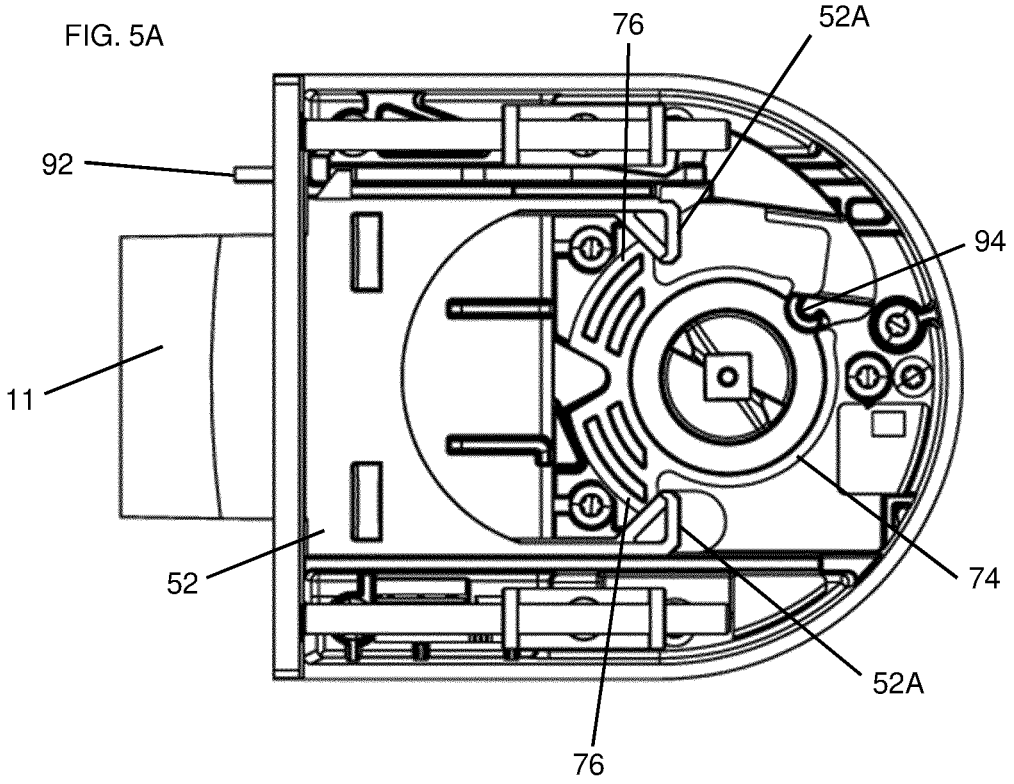


FIG. 5B

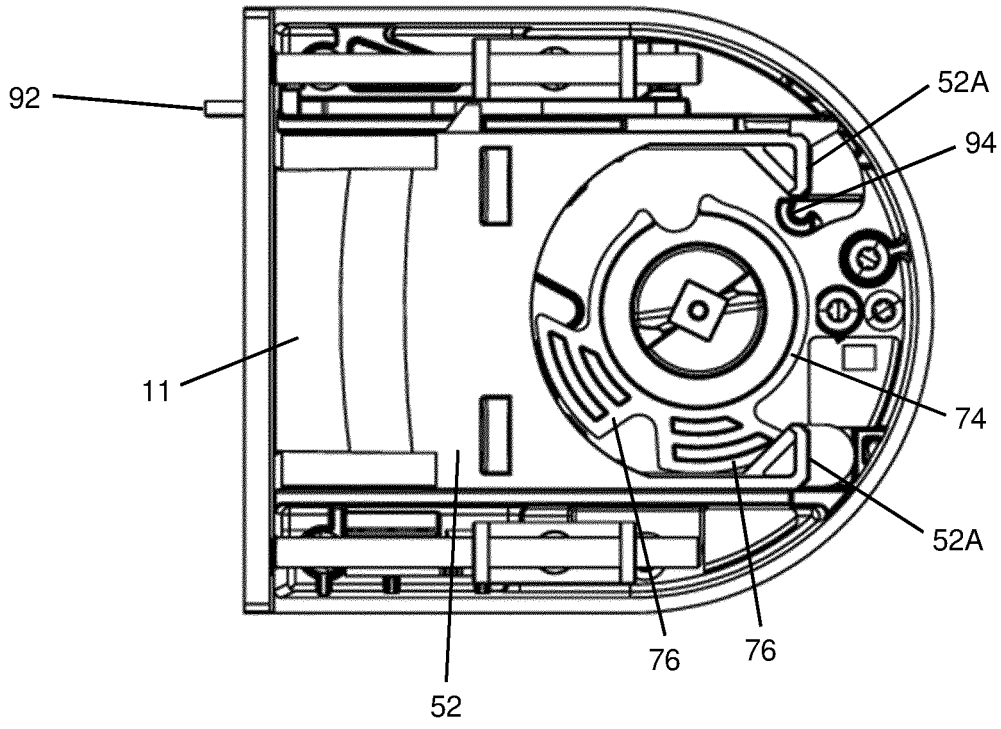


FIG. 6A

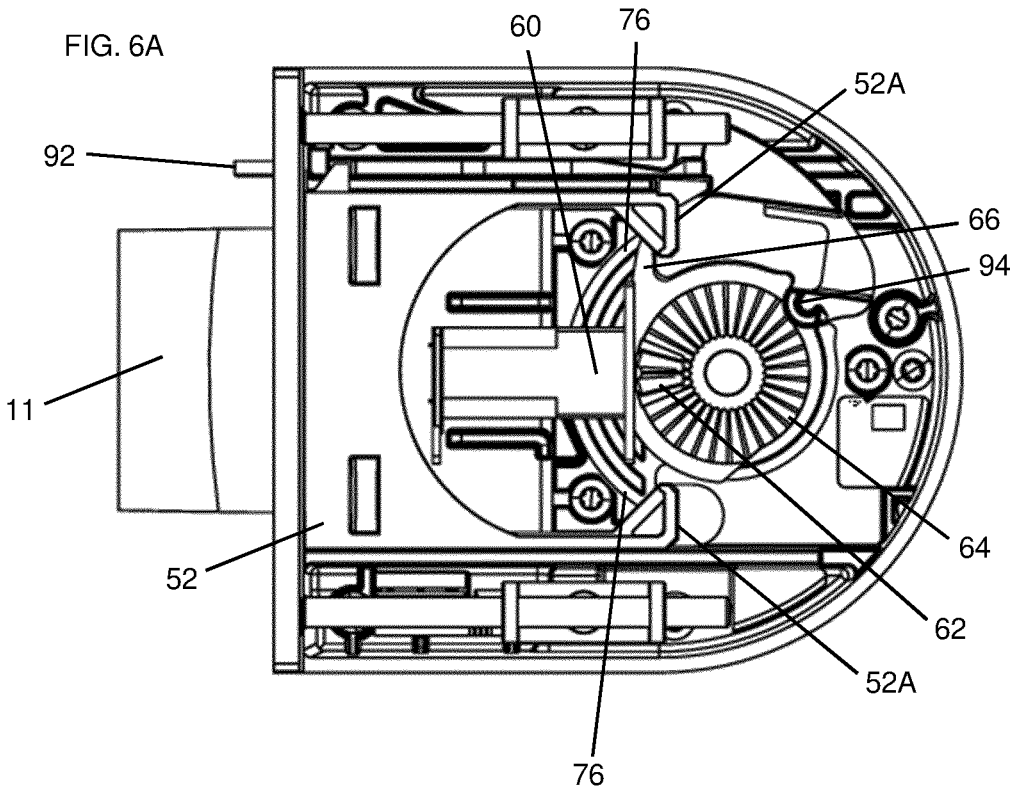


FIG. 6B

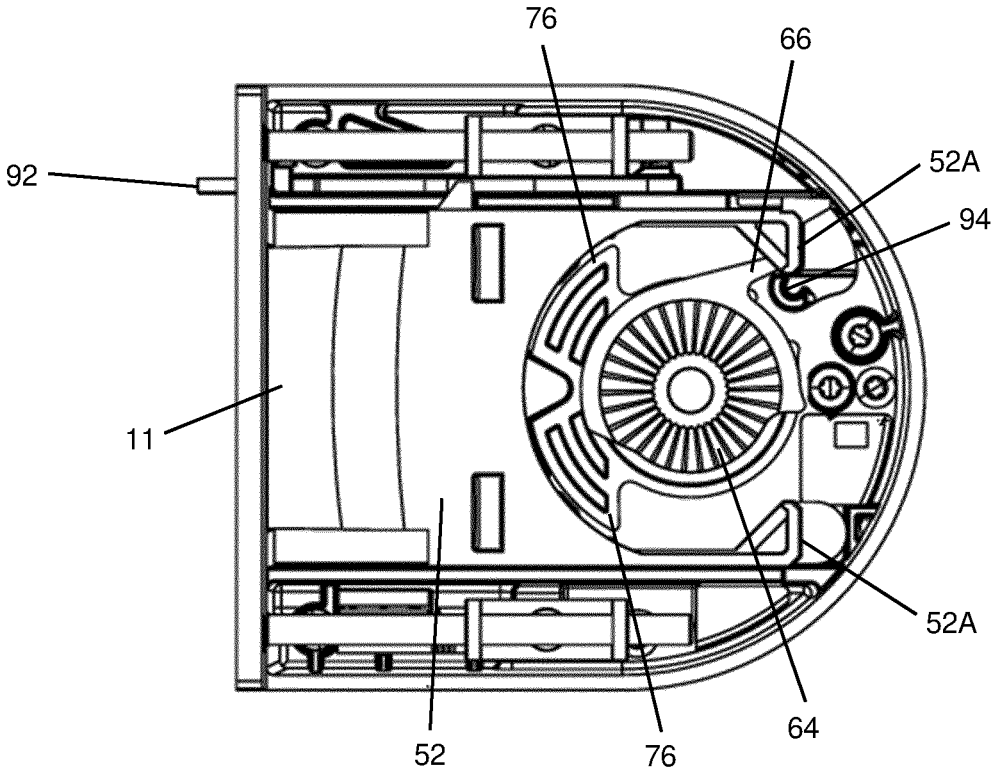


FIG. 7A

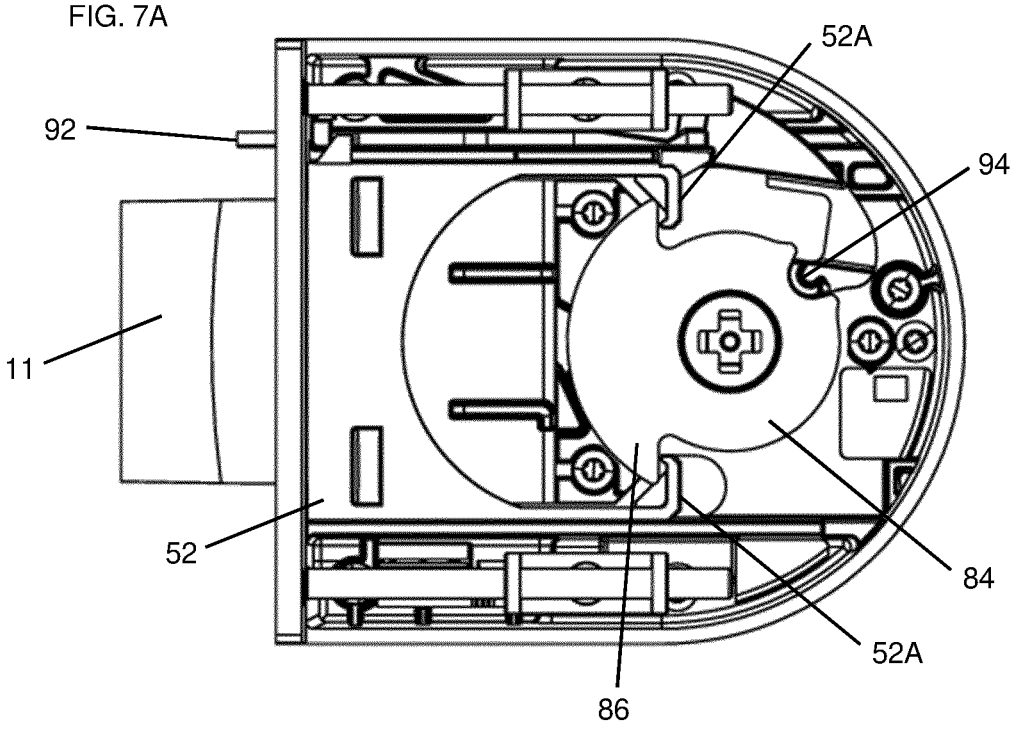


FIG. 7B

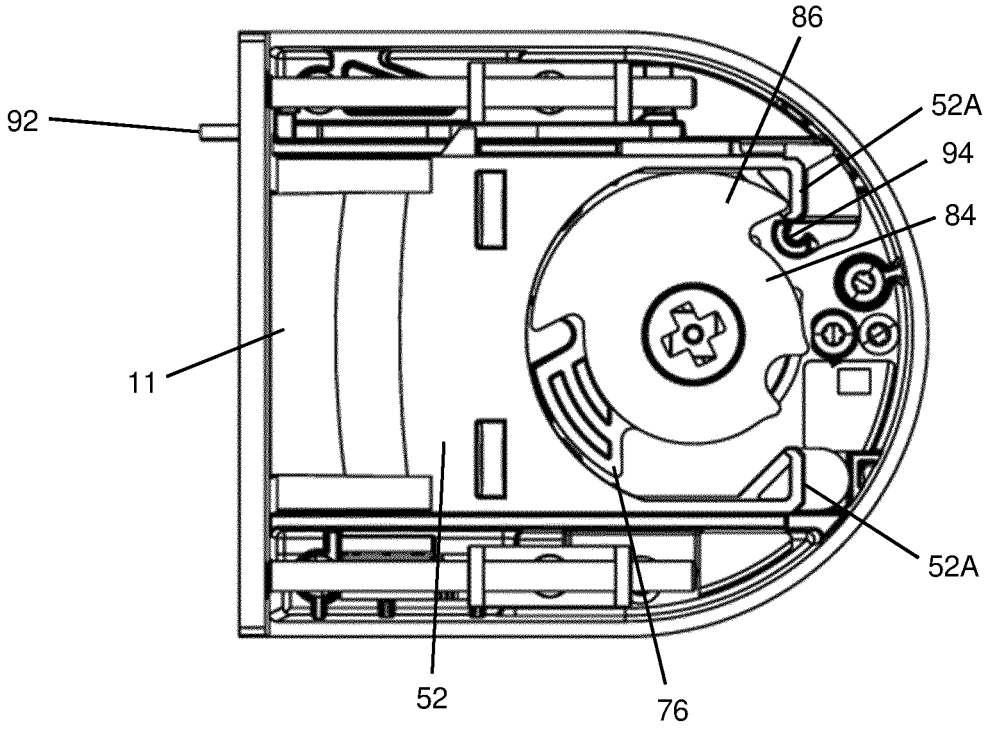
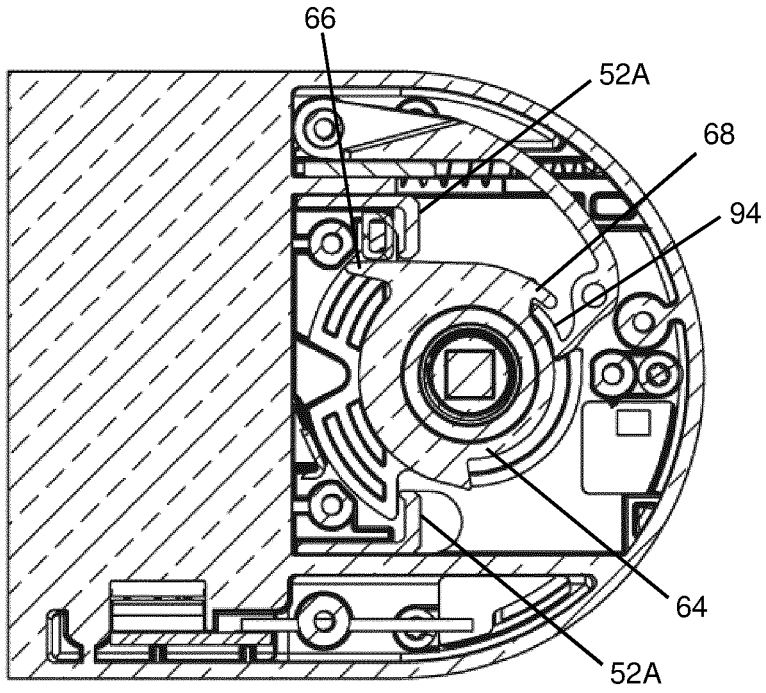


FIG. 8



SMART LOCK

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is a U.S. National Stage application under 35 U.S.C. § 371 of International Application PCT/EP2021/052908, filed Feb. 8, 2021, which claims the benefit of priority to United Kingdom Patent Application GB 2001724.0, filed Feb. 7, 2020. Benefit of the filing date of each of these prior applications is hereby claimed. Each of these prior applications is hereby incorporated by reference in its entirety.

BACKGROUND

The present invention relates to an improved smart lock, in particular an improved lock which includes a latch bolt with an angled front face, such as a rim lock or a sash mortice lock.

A rim lock is a prior art type of lock including a latch bolt with an angled front face which is designed to be mounted on an surface (or rim) of a door or an object, typically on an interior face. For a door, this is the face which can be accessed from the interior of the house or room. This contrasts to a mortice lock which is installed within a cavity in the door or object.

Typically, a rim lock will include a rim lock body or housing which is mounted on the door. A bolt extends from this housing, the bolt can typically be actuated by both an external key and by an internal handle. A keep is provided as the companion piece and is typically mounted on the door frame. The keep includes a cavity for receiving the bolt of the rim lock body in order to prevent the door from opening.

Exemplary rim locks may be found in U.S. Pat. No. 4,313,320 A and 3,006,179 A.

A sash mortice lock is a special type of mortice lock which has both a deadbolt and a latch bolt with an angled front face.

So-called "smart" locks have begun to enter the market for certain lock types, such as Euro Cylinder locks, or other morticed locks. However, these do not easily transfer to rim locks where different considerations are necessary.

A smart lock is an electromechanical lock which is designed to perform locking and unlocking operations on a door when it receives instructions from an authorized remote device, such as a smart phone, typically using a wireless protocol and a cryptographic key to execute the authorization process. The smart lock may also monitor access, or access attempts, and send alerts as necessary to the remote device. Smart locks may be used as a part of a smart home.

CN 105952278 A discloses a mechanical fingerprint lock cylinder and an implementation method.

CN 105155935 A discloses a trigger locking type door.

CN 106930618 A discloses a lock cylinder control system and method.

DE 202009010418 U discuses a door with a movable door leaf which closes an access opening.

FR 3066214 A discloses a method of managing an energy storage means (18) in an electrically autonomous lock.

JP H 08270292 A discloses an acceleration sensor, a car speed sensor and a door lock motor connected to a control section controlling a door lock.

US 2012/0091737 A discloses apparatus for detecting the initial shock of an earthquake and automatically locking a cabinet door before the occurrence of destructive ground motions.

There is therefore a need for an improved smart lock, such as a smart rim lock or a smart mortice lock, or a retro-fit smart lock that operates as a mortice lock.

STATEMENT OF THE INVENTION

The present invention provides a smart lock according to claim **1**.

This allows the state of the door to be sensed with components solely mounted on the door, to avoid the need for additional components to be fitted and aligned on the frame or surrounding area. That is, the sensor can detect the movement of the door without the need for any components mounted on the door frame. By mounted exclusively on the door this means that there is not another component on the fixed element such as the frame.

The sensor may comprise one or more accelerometers. Accelerometers are particularly convenient to detect movement with sensors installed solely on the door.

The sensor may comprise an inertial measurement unit, preferably a six-axis inertial measurement unit. This provides a high degree of accuracy in relation to the movement of the door.

The smart lock may further comprise a user input for receiving a lock command, wherein the controller is configured to: receive the lock command and monitor the signal indicative of the door beginning to move; and control the actuator to actuate the lock mechanism in response to receiving the lock command and the signal indicative of the door beginning to move. This allows the user to trigger locking of the door, for example when they are leaving the property. The beginning to move may be in an opening or closing direction of the door.

The controller may be configured to actuate the lock mechanism a predetermined time period after receiving the signal indicative of the door beginning to open. This delay reduces the risk of the lock being actuated at an inappropriate time which could prevent the lock from correctly locking.

The controller may be configured to actuate the lock mechanism when the signal indicative of the door beginning to open exceeds a threshold value. This threshold value may correspond to an amount of opening of the door. This prevents initial movement of the door incorrectly triggering the lock mechanism.

The threshold value may correspond to the door having passed through at least 5% of its fully open movement, preferably at least 15% of its fully open movement, more preferably at least 25% of its fully open movement. This can be a suitable value to indicate that the door is in an opening process.

The sensor may be configured to detect one of: movement of the housing; or movement of the door. Either of these are suitable to determine the opening process has begun.

The lock mechanism may comprise a bolt, the bolt moveable between a first position where it protrudes from the housing of the smart lock when the lock mechanism is in the locked position and a second position where it is retained within the housing when the lock mechanism is in the unlocked position. This differentiates the smart lock from an adaptor kit where an existing lock mechanism is merely controlled by a smart lock. In such a use case the smart lock is typically only acting as a controller and is not involved with the mechanism of holding the door closed or secure.

The bolt is biased towards the first position by biasing means; and the stall torque of the actuator may be such that

the actuator retains the bolt in the second position against the force of the biasing means. This allows the smart lock to be latched or temporarily retained in the retracted second position without the motor drawing additional power, thereby preserving battery life.

The stall torque of the actuator may be greater than the torque applied on the actuator by the biasing force of the biasing means when the bolt is in the second position. This stall force is not overcome by the biasing force such that the smart lock can be latched or temporarily retained in the retracted second position without drawing additional power, thereby preserving battery life.

The bolt may comprise a recess arranged to receive the actuator when the latch bolt is in the second position. This allows the bolt length to be maximised while effectively mounting the components within the housing. One or more other components may also be received in this recess in the second position including but not limited to a battery; a circuit board; a controller; a receiver; and/or a transmitter.

The bolt may have a bolt throw of between 14 millimetres to 20 millimetres. Such a bolt throw provides a high level of security.

The smart lock may be a rim lock and comprise the lock mechanism. In a rim lock arrangement, the actuator and the lock mechanism are contained within the housing and are attachable to the surface of the door. This contrasts to a mortice lock where the lock mechanism is within the door. In use, the user pushes the door shut with the latch bolt in an extended position. As the angled face of the latch bolt contacts the keep, or strike plate, it is pushed back against the biasing force. Once the latch bolt is entirely aligned with the keep, or strike plate, the biasing force then returns the latch bolt to the extended position to lock the door.

The lock may be a mortice lock and the lock mechanism is contained within the door and further comprises a deadbolt. An example of a mortice lock is a sash mortice lock which includes a deadbolt and a latch bolt with an angled face. The benefits of the motion sensing can therefore be applied to such a lock. In such a lock the lock mechanism is not a part of the smart lock but is instead a component of the door.

When the lock is a sash mortice lock, the locked position of the lock mechanism may include a first locked position where the latch bolt protrudes from the door and a second locked position where the latch bolt and the deadbolt protrude from the door. Thus the lock can provide multiple levels of security.

When the lock is a sash mortice lock, the lock mechanism may be moveable in order from the second locked position, to the first locked position, to the open position. That is, from a fully locked position first the deadbolt is retracted followed by the latch bolt with the angled face. This means that both bolts can be controlled by the same mechanism.

BRIEF DESCRIPTION OF THE FIGURES

FIG. **1** shows a cross-section of a prior art rim lock;

FIG. **2** shows a perspective view of a smart rim lock according to the present invention;

FIG. **3** shows a cross-section of the smart rim lock of FIG. **2**;

FIG. **4** shows a further cross-section of the smart rim lock of FIG. **2**;

FIGS. **5**A and **5**B show a top view of the smart rim lock of FIG. **2** being operated via a key, with components omitted for ease of reference;

FIGS. **6**A and **6**B show a top view of the smart rim lock of FIG. **2** being operated via an actuator, with components omitted for ease of reference;

FIGS. **7**A and **7**B show a top view of the smart rim lock of FIG. **2** being operated via a handle, with components omitted for ease of reference; and

FIG. **8** shows a cross-section of a smart rim lock with a modified motor cam.

DETAILED DESCRIPTION

A prior art rim lock is shown in FIG. **1**, which is modified from 4 313 320 A. While U.S. Pat. No. 4,313,320 A is specifically directed to the implementation of what they describe as a "classroom" function, the general working principles of a rim lock are the same. While some of the improvements discussed in relation to the present invention are specific for rim locks **100**, it is also appreciated that any improvement can also be applied to other types of locks, such as mortice locks, as appropriate.

The rim lock **100** comprises a rim look body **10** and a keep **20**. The rim lock body **10** is mounted onto a closure such as a door **30**. The rim lock body **10** may also be generally referred to as a housing **10** for the rim lock **100**. The door **30** may be a door for ingress into a room, or may be a door for a cupboard, safe or any other suitable closure. The rim lock body **10** is be attached to the door **30**, for example via attachment means such as screws passing through a back plate **12**. It is possible to attach the rim lock body **10** directly to the door **30**. However, the best practice is to use such a back plate **12**. The rim lock body **10** may then snap-fit or attach to the back plate **12** via any known mechanism.

On the opposite side of the door **30**, there is provided a key plate **14** with a keyhole for receiving a key to operate the rim lock **100**. A key cylinder **16** extends from this key plate **14**. The key cylinder **16** is a typical barrel cylinder which operates according to the known principles to rotate when the correct key is inserted into the keyhole and turned. A tail piece **18** extends from the key cylinder **14**. The tail piece **18** turns when a key inserted into the key cylinder **16** is turned. The key cylinder **16** extends into a bore formed in the door **12** and the tail piece **18** extends therefrom to pass through the back plate **12** into the rest of the rim lock body **10**.

The keep **20** is attached to a frame **40** of the door **30**. Alternatively, the keep **20** may be formed within the frame **40** of the door. The frame **40** may be a specifically designed door frame, or may merely be the surrounding surface adjacent the door **30**. The keep **20** includes a cavity **22** which is arranged to receive a bolt **11**. When the keep **20** receives the bolt **11**, the rim lock **100** inhibits and prevents the door **30** from opening.

The bolt **11** is operated between a locked (or closed) position and an unlocked (or open) position by a lock mechanism **50** within the rim lock body **10**. This lock mechanism **50** can be actuated either by a key inserted into the keyhole, or via rotation of a handle **17**, known in the art as a thumb turn **17**.

The rear of the bolt **11** is formed with a transverse slot which receives the front end of a draw plate **53** to which the head is attached, for example by a pair of pins. However, this is a particular of the specific design and many other variations exist. For example, the draw plate **53** may be integrally formed with the bolt **11**.

A crank arm **57** is mounted for rotation with the thumb turn **17**. A crank pin **56** extends through the plane of the bolt draw plate **53**. Rotation of the thumb turn **17** thus moves the draw plate **53** to retract the bolt **11**.

Likewise, the tail piece **18** is attached to a T-shaped cam **54** which is rotatably mounted in the rim lock body **10**. This cam **54** includes cam arms **55** which engage the crank pin **56** and rotates with the key so as to move the draw plate **53** to retract the bolt **11**. The cam arms **55** form the wings of the T-shape extending from the central portion.

In this sense, the lock mechanism **50** can be actuated either by the thumb turn **17** or the key cylinder **14**.

A rim lock **100** according to the present invention is shown in perspective in FIG. **2**. As can be seen from this Figure, the rim lock **100** generally comprises a rim body, or housing, **10** and keep **20** as in the prior art rim lock **100**. Unless expressly specified otherwise, common features of the smart rim lock **100** are as described in relation to the prior art rim lock **100** of FIG. **1**. The key difference that makes the rim lock "smart" is that it includes an actuator and a receiver configured to wirelessly receive a signal to control operation of the actuator. This allows the smart rim lock **100** to be connected to, for example, the Internet of Things. Thus the smart rim lock **100** can be controlled remotely via a user on a remote device, as well as manually locally via the handle **17** or a key. For example, the user may be able to actuate the smart rim lock **100** with be an application (app) on a user's smart phone.

FIGS. **3** and **4** show cross-sectional views of the rim lock **100** of FIG. **2**. The rim lock **100** comprises a latch bolt **11** (referred to for simplicity as bolt **11**) which is connected to a throw arm **52**. The throw arm **52** may be integral with the bolt **11** or may be formed as a separate component attached thereto. The throw arm **52** is formed as a central body with two throw arms **52**A extending from opposite sides therefrom into the rim body **10** away from the bolt **11**. The bolt **11** and the throw arms **52** form a lock mechanism. It is possible for the lock mechanism to have one or more throw arms **52**.

The bolt **11** is moveable between a first position, also known as a locked position, shown in FIG. **3** in which the bolt **11** extends into the cavity **22** of the keep **20** to prevent the door **30** from being opened and a second position, also known as an unlocked position, where the bolt **11** is retracted from the keep **20** such that the door **30** can be opened. The bolt **11** is biased towards the locked position by one or more biasing means, which may be a resilient member such as one or more springs **15**, but could also be any element which provides a biasing force such as a magnet.

The bolt **11** may have a bolt throw of 14 millimetres to 20 millimetres, or of at least 20 millimetres. Other sizes of bolt throw are also possible, but generally result in a less secure lock, which should not be used as a single lock on a door. The bolt throw is the distance the bolt **11** travels under the action of the key to retract it from the keep **20**. That is, the amount the bolt **11** extends from the body **10** into the keep **20**. A bolt throw in this range allows the rim lock **100** to be compliant with the highest security levels of current standards as a longer bolt throw generally corresponds to a more secure lock. For example, this may be British Standard BS3621, or BS8621, or TS621 which is specifically a standard for smart locks. If the rim lock **100** is complaint with the highest level of the relevant standard it may be used as the sole lock on the door **30**. Otherwise, a secondary lock may be necessary, such as an additional five lever mortice lock. In particular, many insurers require a lock compliant with BS3621 to be provided on the door **30** in order for home and contents insurance to be valid.

The total bolt throw needs to be able to be received in the rim lock body **10** when the bolt **11** is retracted. In conventional rim locks (such as FIG. **1**) this is not a particular issue as there are large amounts of empty space within the rim lock body **10**. However, the smart rim lock **100** of the present invention also needs to house the actuator **60** (in the particular embodiment, the actuator **60** is a motor **60**, but any other suitable actuator **60** may be used), battery **61**, and the associated circuitry and mechanisms.

As such, in the present invention the bolt **11** is cored out to form a recess **11**A. when the bolt **11** is retracted in the unlocked position, the recess **11**A receives the motor **60**. In other words, the bolt **11** is formed of head which is full-sized according to prior art locks, with a thin body portion **11**B extending therefrom. The thin body portion **11**B may have a thickness of less than 10 millimetres, preferably less than 5 millimetres.

In use, the various cams engage with the throw arms **52**A to retract the bolt **11**. The lock mechanism **50** is individually actuatable by each of an actuator cam **64** (also known as a motor cam **64**), a handle cam **74** (also known as a thumb turn cam **74**) and a key cam **84**. Each of these cams are rotatably mounted within the rim lock body **10** about generally coincident axes of rotation. This axis of rotation is generally transverse, or perpendicular, to the direction of movement of the latch **11**. The cams **64**, **74**, **84** are each independently rotatable within the rim lock **100**. The key cam **84** is nearest the door **30**, and the handle cam **74** is further the door **30**. The motor cam **64** is between the key cam **84** and the handle cam **74**.

The smart rim lock **100** may further comprise a controller, memory, processors, a receiver for wireless communication, a transmitter for wireless communication, etc. The controller may control actuation of the motor **60** to move the bolt **11** between the unlocked and locked positions. The receiver is able to wirelessly receive a user command to move the bolt **11** between the unlocked and the locked position. The wireless communication may be via any suitable protocol, for example Bluetooth, Wi-Fi, Li-Fi, or any combination of these. The user command may be transmitted directly from a user's remote device such as a smart mobile phone, preferably via a companion application. Alternatively, or additionally, the smart rim lock **100** may communicate with a smart hub which itself is in communication with the user's remote device.

In order to improve connectivity of the receiver, the back plate **12** of the smart rim lock **100** may be formed of material which is relatively conductive of the communication protocol. For example, the back plate **12** may be formed of as plastic such as glass filled polycarbonate.

FIGS. **5**A and **5**B, **6**A and **6**B, and **7**A and **7**B show the opening movements for each of the thumb turn opening, motor opening, and key opening respectively. In each of these Figures, the biasing members **15** have been hidden to allow the respective mechanisms to be more easily viewed. The actuator or motor **60** has been omitted from each Figure except for FIG. **6**A, for the same reason. The motor **60** may be positioned between any of the cams **64**, **74**, **84**.

FIG. **5**A shows a partial cross-section of the rim lock **100** to illustrate opening via the thumb turn **17** (also known as a handle). The thumb turn cam **74** is rotatably mounted within the rim lock body **10** as described above. The thumb turn cam **74** comprises one or more radially extending protrusions **76**. The radially extending protrusions **76** are arranged to engage with the throw arms **52**A as the thumb turn cam **74** is rotated. In use, the thumb turn **17** is rotated by a user. This causes the thumb turn cam **74** to likewise rotate. As the thumb turn cam **74** rotates the protrusion **76** engages with the throw arm **52**A to actuate the lock mechanism and retract the bolt **11** as shown in FIG. **5**B. The thumb turn cam **74**, and

the components operatively connecting the thumb turn **17** and the thumb turn cam **74** form the thumb turn mechanism or handle mechanism.

As shown in the example of FIGS. **5**A and **5**B the thumb turn protrusions **76** extend over enough of the circumference of the thumb turn cam **74** that the thumb turn cam **76** can be rotated in either direction to retract the bolt **11**. While the depicted example has two thumb turn protrusions **76**, the same effect could be achieved with a single thumb turn protrusion **76** which may extend over the same circumferential extent of the thumb turn cam **76**.

A clutch arm **94** is provided, actuated by a snib **92**. This clutch arm **94** acts to prevent the smart lock **100** from being forced open (jimmied). The clutch arm **94** is biased towards a position as shown in FIG. **5**B where it is disengaged from the key cam **74**. In this position the snib **92** it in its most extended position from the smart lock **100**. When the door is closed, the snib **92** engages a face on the keep **20**, forcing it to retract. This movement of the snib **92** then moves the clutch arm **94** to the position shown in FIG. **6**A where it engages with the key cam **64**. In this position, the clutch arm **94** prevents the bolt **11** from moving. A further arrangement of the clutch arm **94** is shown in FIG. **8** and described below.

Actuation of the lock mechanism using the motor **60** is shown in FIGS. **6**A and **6**B. Attached to the output shaft of the motor is a bevel gear **62**. This bevel gear **62** engages with a corresponding geared surface on the motor cam **64**. Thus, actuation of the motor **60** drives rotation of the bevel gear **62** and hence rotation of the motor cam **64**. The motor cam **64** is provided with a motor cam protrusion **66**. As the motor cam **64** rotates the motor cam protrusion **66** engages with the throw arm **52** to thereby retract the bolt **11** to the unlocked position. The motor bevel gear **62** and motor cam **64** form the motor mechanism. While the motor cam protrusion **66** could be similar to the thumb turn protrusion **76** in that it could be shaped so that the motor cam **64** can rotate in either direction to actuate the lock mechanism, this is not necessary. Instead, additional functionality can be imparted into the smart lock **100** as discussed below by having the motor cam **64** have a single direction of operation to actuate the bolt **11**.

The smart lock **100** may be retained in the unlocked position shown in FIG. **6**B to latch the lock **100**. This may be used when the user does not want the door **20** to be locked, for example if they are heading out briefly such as to take out their garbage. Typically, this is achieved with a mechanical button on the face of the rim lock **100**. This mechanical button can only be operated from within the property. As described above, the springs **15** are acting to bias the bolt **11** towards the locked position. Accordingly, the biasing force provided by the springs **15** needs to be overcome to retain the bolt **11** in the unlocked position of FIG. **6**B. While this could be achieved by providing a constant output from the motor **60**, this requires additional energy usage and hence a faster rate of drain of the battery **61**.

Instead, it is preferable if the motor **60** and biasing member(s) **15** are selected such that the motor stall torque is greater than the torque transferred to the motor from the force of the biasing member(s) **15**. Thus, the motor **60** is able to retain the bolt **11** in the unlocked position without drawing additional power. For example, the motor stall torque may be in the region of greater than 0.25 Nm, preferably greater than 0.275 Nm, most preferably greater than 0.29 Nm. Of course, the particular value for motor torque must be selected based upon the biasing member(s) **14** chosen and the particular mechanism. Such values of motor stall torque may be suitable, for example for biasing member(s) **14** which exert an opposing torque in the region of 2.5 Nm. The gearing connecting the motor **60** may be selected to gear up to this. This may be biasing member(s) **14** which provide a force in the region of 10 N to 11 N. The biasing force may be prescribed a minimum value in order to meet security levels of a particular standard, in a similar manner to the bolt throw.

This latching position may be triggered by a user pressing a button **19** on the rim lock **100**, or on a remote device such as their mobile phone which is then transmitted to the rim lock **100**. The button **19** may be, for example, provided on the thumb turn **17** as shown in FIG. **2**. The smart lock **100** may include a transmitter for communication with a remote device, such as a user's smart phone or a smart hub. This allows the smart lock **100** to send the user an alert or notification when the latching has been engaged, to reduce the chance that the door **20** is accidentally left latched.

FIGS. **7**A and **7**B show operation of the rim lock **100** when actuated by the key. The key cam **84** is connected to the tail piece **18** of the key cylinder **16**. In particular, there may be a slot arranged to receive the tail piece **18** of the key cylinder. As the tail piece **18** rotates when the correct key is inserted into the keyhole and turned, the cam **84** likewise rotates. The cam **84** comprises a key cam projection **86** which engages with the draw arm **52**A to thereby retract the bolt **11** in a manner similar to the thumb turn cam **74** and motor cam **64**. The connection between the tail piece **18** and the key cam **84**, and the key cam **84**, form the key mechanism.

For high security rim locks **100**, it is preferable if the rim lock **100** can be placed into a state where the bolt **11** is not moveable from the locked position by one or both of the thumb turn **17** or the key cylinder **16**. For example, overnight a user may wish to disable the key cylinder **16** so that even an intruder with the correct key cannot open the door **30**. This may be useful, for example, where keys are borrowed by third parties. When a user is leaving their property for a long period of time they may wish to disable the thumb turn **17**. This prevents an intruder that has accessed the property via another entry point (such as via a window) from being able to exit via the door **30**. This may make it harder for the intruder to steal high value items which are difficult to transport through the initial entry point, such as a large television.

The smart rim lock **100** according to the present invention may disengage the key mechanism or the handle mechanism from the lock mechanism in order to prevent either the key cylinder **16** or thumb turn **17** from actuating the lock mechanism to move the bolt **11** to an unlocked position. In particular, this may be achieved via movement of the motor cam **64**.

In particular, the motor cam **64** may be rotated in a direction opposite to the direction it rotates in to open the bolt **11** in order to disengage one or both of the thumb turn cam **74** and the key cam **84** from the lock mechanism. For example, the thumb turn cam **74** or key cam **84** may be moved in the direction of their axis of rotation. This may then move the cam **74**, **84** out of alignment with the throw arms **52**A. Then, the cams **74**, **84** are able to freely rotate within the rim lock **100** without engaging the throw arms **52**A. Accordingly, even as the cams **74**, **84** rotate they will not engage the throw arms **52**A and hence will not move the bolt **11** to the unlocked position.

This may be achieved by the motor cam **64** having one or more ramped surfaces on its faces. These ramped surfaces can then engage with corresponding surfaces on the thumb

turn cam **74** and/or key cam **84** so as the move them out of alignment with the throw arms **52**A. With the thumb turn cam **74** and/or key cam **84** out of alignment, they may engage with a protrusion on the housing of the smart lock **100** that prevents them from further movement or rotation.

Alternatively, or additionally, there may be a hooked surface on the motor cam **64**. This hooked surface can engage the clutch arm **94** and therefore retain the thumb turn cam **74** and/or the key cam **84** in place. An example of this arrangement is shown in FIG. **8** and discussed below.

Thus, the thumb turn **17** and/or the key cylinder **16** can be effectively de-activated from controlling the lock mechanism.

FIG. **8** shows a further arrangement of the clutch arm **94** and motor cam **64**, which may be applied to any of the arrangements described above. The smart lock **100** is generally as described above, and the operation of the various cams is as described above.

The motor cam **64** is provided with a protrusion **66** engages with the throw arm **52** to thereby retract the bolt **11** to the unlocked position. The motor cam **64** shown in FIG. **8** will rotate in an opposite direction (counter-clockwise based upon FIG. **8**) compared to the motor cam **64** of FIGS. **5**A to **7**B. This does not fundamentally affect operation of the smart lock **100**.

The motor cam **64** further comprises a hook **68**. With the clutch arm **94** in the position engaging the key cam **84** (i.e. the door **30** is closed and the smart lock **100** is in the locked position), the motor cam **64** can be rotated such that the hook **68** engages with the clutch arm **94**. The hook **68** engages with the clutch arm **94** and retains it in this position as shown in FIG. **8**. Thus, the key cam **84** cannot rotate to open the smart lock **100**. The rotation of the motor cam **64** to engage the hook **68** may be in the opposite direction to the rotation of the motor cam **64** to actuate the bolt **11**.

The clutch arm **94** may further comprise a shoulder which abuts against at least one of the throw arms **52**A of the bolt **11** in the locked position when the clutch arm **94** engages the key cam **84**. Thus the clutch arm **94** may physically prevent the bolt **11** from moving.

With the bolt **11** in the latched position (i.e. retained by the motor **60** after an opening event), a user may wish to instruct the lock to close after the door has been shut. For example, this may be relevant if someone has used the app to move the bolt **11** to the unlocked position and they now wish to secure the door **30**. Alternatively, a user approaching a locked door **30** may send a user input to the smart lock **100** that they would like to open the door.

In order to achieve this the rim lock **100** may include a timer which actuates the bolt **11** from the unlocked position to the locked position, or from the locked position to the unlocked position, after a predetermined time delay which may be triggered by the receipt of a user input. However, this may be unsuitable for many use cases. For example, if the user is not close to the door **30** when they send the signal to open the rim lock **100** this predetermined time delay may expire before the user reaches the door **30**. This could be the case, for example, where a user is transporting an item such as shopping from a car. On the opposite side, if a user is very close to the door **30** when the send the opening command they may be able to open the door **30** and pass therethrough and go to shut the door before the predetermined time has expired. This may mean that the door **30** bounces back out of locked position, so that at the expiry of the predetermined time the bolt **11** is no longer aligned with the keep **20** and hence when the bolt **11** is moved to the locked position it is not retained within the keep **20** and hence the door **30** is unsecured.

In order to solve this, the rim lock **100** may comprise one or more sensors which are able to detect movement of the door **30** or an element attached to the door **30**. Particularly, the sensors may detect when the door begins to open. While this could be achieved by having corresponding sensors, or elements of sensors on either side of the door **30** and frame **40**, this is not a preferable solution as it requires a consistent alignment between these. Further, as this is an additional part it increases the cost and complexity. Many customers do not want to install another thing to their door or frame, and some door frames may be unsuitable for this based upon its thickness or architrave profile.

Instead, according to the present invention the movement of the door **30** is sensed by components solely, or exclusively, attached to the door **30**. That is, there is a standalone sensor system which is able to detect movement of the door **30** without requiring any additional sensors mounted elsewhere. Of course, there may be additional sensors detecting other parameters mounted elsewhere.

After movement of the door **30** is sensed, the controller may control the motor **60** to actuate the lock mechanism to move the bolt **11** to the locked position. As in the present example the bolt **11** has a latch profile. That is, bolt **11** has an angled front face which allows the door **30** to be closed when the bolt **11** is in the locked position as the angled front face slides against the face of the keep **20** to retract the bolt **11** against the biasing member(s) **15**. Particularly, the face of the bolt **11** which first contacts the keep **20** during a closing movement of the door may form an angle of between 20° to 70° with a first point of contact of the keep **20**. The angle may be between 30° to 60°.

That is, the bolt **11** may have a generally right trapezoid shape when viewed in cross-section in a direction along its plane of movement. The bolt **11** may therefore by a right trapezoidal prism. Of course, deviations from the strict mathematical shape are still covered by this. The angled face may be curved rather than at a straight line. The relevant angle can then be defined based upon a tangent of this curve. Once the bolt **11** is aligned with the cavity **22** of the keep **20** the biasing members(s) **15** then return the bolt **11** to the locked position and thereby lock the door **30**. This may be an active movement or it may be from a biasing force. Accordingly, the user can then push the door **30** closed from this position.

In particular, the lock may comprise an accelerometer to detect closing of the door **30**. The accelerometer may sense the acceleration of the door **30**, or of a component within the lock to detect the movement of the door **30**. The accelerometer may be a part of an inertial measurement unit, such as a six-axis inertial measurement unit. Alternatively, any suitable sensor to detect movement of the door **30** may be used, such as a compass.

In particular embodiments, the smart rim lock **100** may also use a predetermined time delay. For example, the signal from the sensor may indicate that the door **30** has begun opening and a time delay may then begin before the bolt **11** is actuated to the locked position.

The controller may "learn" what opening of the particular door **30** looks like on the signal from the sensor by instructing the user to carry out a number of opening repetitions and recording the signal and storing this in some memory. In future opening events the signal received from the sensor may be compared to the stored signal to identify an opening event.

This method of determining when a door **30** has begun opening in order to actuate a lock mechanism may be applied more generally to any smart lock, whether it is a rim lock or otherwise. For example, this method may be applied to a smart lock for a mortice lock. The smart rim lock **100** may determine when the door has passed through a threshold opening amount, in order to distinguish over small movements when the door **30** is still closed. For example, the smart rim lock **100** may monitor for the door **30** past a threshold value which corresponds to the door being 5% of its fully open movement, preferably at least 15% of its fully open movement, more preferably at least 25% of its fully open movement.

The motion sensing of the door **30** may also be used to determine if, for example, the door has been opened by force such as being kicked in. The controller may detect that the door has begun to move, and that the lock mechanism has not been actuated. This may trigger a notification or alert, such as to a user's remote device.

In many situations, the smart rim lock **100** of the present invention will be used to replace a user's existing standard rim lock. For example, a user may be upgrading their existing rim lock to a smart rim lock **100**. In such a scenario, the user may not want to change their keys. Therefore, the smart rim lock **100** according to the present invention can be used to replace an existing rim lock without replacing the key cylinder **16**.

In order to carry out the replacement of an existing rim lock, the following steps may take place. Firstly, the rim lock body **10** of the previous rim lock may be detached from the back plate **12**. The detachment of the rim lock body **10** will also typically detach all of the mechanisms of the previous rim lock. The back plate **12** is then detached from the door **30**.

The key cylinder **12** is retained within the door **30** and not removed. A new back plate **12** suitable for the present smart rim lock **100** is then attached to the door **30**. This may involve the door **30** having to be chiselled to account for any differences in the overhang of the bolt face between the existing rim lock and the new smart rim lock **100**. As discussed above, the back plate **12** for the smart rim lock **100** may be more conductive of wireless signals than the back plate **12** of the previous rim lock **100**.

With the new back plate **12** attached to the door **30**, the rim lock body **10** of the smart rim lock **100** can then be attached to the back plate **12**. The rim lock body **10** will have an opening in the key mechanism for receiving the tail piece **18** of the previous key cylinder **16**.

While the keep **20** of the previous rim lock may not need to be replaced if it aligns with the latch **11** of the smart rim lock **100**, it is preferable that it is replaced with the keep **20** for the smart rim lock **100** to ensure compatibility.

The smart rim lock **100** is thus installed on the door **30** to replace the previous rim lock without the need to replace the key cylinder **16**. The user thus achieves the smart functionality without having to replace their keys.

This means that the smart rim lock **100** according to the present invention may be sold as a standalone item without a key cylinder **16**. Alternatively, or additionally, a kit may be sold of the smart rim lock **100** with a key cylinder **16**.

In particular, this method of replacement of an existing rim lock with a smart rim lock **100** may include the steps of: removing the housing **10** from the back plate **12**; and then removing the back plate **12** from the door **30**. The key cylinder **16** of the existing rim lock can then be kept. The smart rim lock back plate **12** is then installed onto the door **30**. The smart rim lock **100** is then attached to the smart rim lock back plate **12**. This attachment to the smart rim lock back plate **12** is so that the tail piece **18** is received by the smart rim lock **100** in an operable connection such that actuation of the key cylinder **12** actuates the key mechanism of the smart rim lock **100**.

As discussed above, the motion sensing of the door **30** may be applied to other types of smart lock and not just a rim lock. A particular example of this is a mortice sash lock. With such a lock, there is a deadbolt and a latch bolt **11** which may both be controlled by a single tail piece **18**. The latch bolt **11** may be generally similar to the latch bolt **11** described above, particularly in that it may be biased towards the extended position. The deadbolt does not include such an angled face and is generally a rectangular cuboid. Unlike a rim lock, the latch bolt **11** and lock mechanism are retained within the door **30**, as opposed to the housing **10** of a rim lock. Thus, the latch bolt **11** protrudes from a side face of the door **30** to be received in a keep **20** or strike plate which may be formed into the door frame.

With the mortice sash lock in the fully locked position both the deadbolt and the latch bolt **11** are extended and locking the door **30**, this is a second locked position of the lock mechanism **50**. As the tail piece **18** rotates, the deadbolt is first retracted, but the latch bolt **11** is still extended. This is a first locked position of the lock mechanism **50**. Further rotation of the tail piece **18** causes the retraction of the latch bolt **11** such that the lock mechanism **50** is in the unlocked position. When this is done by a user with a key in a key cylinder **16**, the user will hold the key in the cylinder **16** to maintain the latch bolt **11** in the retracted position against the biasing force.

When the lock mechanism of the mortice sash lock is actuated via the actuator **60**, the actuator **60** drives the lock mechanism **50** so as to first retract the deadbolt and then the latch bolt **11**. If the actuator **60** were turned off the biasing force would drive the latch bolt **11** back to the extended position. If the door **30** were not yet open, such as if the user triggered the unlocking and was not immediately ready to open the door **30**, the latch bolt **11** would then extend back into the keep **20** and prevent the door **30** from opening.

Thus, in a similar manner as to the rim lock **100**, the mortice sash lock may comprise one or more sensors which are able to detect movement of the door **30** or an element attached to the door **30**. This generally operates in the same manner as discussed above in relation to the rim lock **100**.

The user triggers the actuator **60** to open the mortice sash lock, this causes the actuator **60** to rotate the tail piece, or lock cylinder, to first retract the deadbolt and then retract the latch bolt **11**. The motor **60** stall torque is then used to hold the latch bolt **11** in the retracted position against the biasing force. After movement of the door **30** is sensed, the controller may control the motor **60** to actuate the lock mechanism to move the latch bolt **11** to the locked position. This may be an active movement or it may be from the biasing force. That is, the motor **60** may actuate the latch bolt **11** to a neutral position from which the latch bolt **11** can be moved to a fully extended position via the biasing force. This then allows the user to push the door **30** closed, after which the actuator may continue to actuate the deadbolt to fully lock the door.

The sensing mechanism may be as described above and may include any suitable variations and examples included. In this sense, the motion sensing may be applied to other lock types than a rim lock.

The invention claimed is:

1. A smart lock for securing a door comprising:

a housing mountable to the door;

an actuator within the housing configured to actuate a lock mechanism between a locked position and an unlocked position, the lock mechanism including a latch bolt with an angled front face, the latch bolt configured to be retractable against a biasing force provided by a biasing means such that the door is closeable when the lock mechanism is in the locked position; and

a receiver within the housing configured to wirelessly receive a signal to control operation of the actuator;

a sensor mountable exclusively to the door so as to generate a signal indicative of the door beginning to move in an opening or closing direction of the door;

a controller arranged to receive the signal indicative of the door beginning to move in an opening or closing direction of the door, the controller configured to control the actuator to actuate the lock mechanism from the unlocked position to the locked position in response to the signal indicative of the door beginning to move in an opening or closing direction of the door.

2. The smart lock of claim 1, wherein the sensor comprises one or more accelerometers.

3. The smart lock of claim 1, wherein the sensor comprises an inertial measurement unit, preferably a six-axis inertial measurement unit.

4. The smart lock of claim 1, further comprising a user input for receiving a lock or an unlock command, wherein the controller is configured to:

receive the command and monitor the signal indicative of the door beginning to move in an opening or closing direction of the door; and

control the actuator to actuate the lock mechanism in response to receiving the command and the signal indicative of the door beginning to move in an opening or closing direction of the door.

5. The smart lock of claim 1, wherein the controller is configured to actuate the lock mechanism a predetermined time period after receiving the signal indicative of the door beginning to move in an opening or closing direction of the door.

6. The smart lock of claim 1, wherein the controller is configured to actuate the lock mechanism when the signal indicative of the door beginning to move in an opening or closing direction of the door exceeds a threshold value.

7. The smart lock of claim 6, wherein the threshold value corresponds to the door having passed through at least 5% of its fully open movement, preferably at least 15% of its fully open movement, more preferably at least 25% of its fully open movement.

8. The smart lock of claim 1, wherein the sensor is configured to detect one of:

movement of the housing; or

movement of the door.

9. The smart lock of claim 1, wherein the smart lock is a rim lock, and comprises the lock mechanism.

10. The smart lock of any claim 9, wherein the latch bolt is moveable between a first position where it protrudes from the housing when the lock mechanism is in the locked position and an second position where it is retained within the housing when the lock mechanism is in the unlocked position.

11. The smart lock of claim 10, wherein the latch bolt is biased towards the first position by biasing means, and a stall torque of the actuator is such that the actuator retains the bolt in the second position against the force of the biasing means.

12. The smart lock of claim 11, wherein the stall torque of the actuator is greater than the torque applied on the actuator by the biasing force of the biasing means when the latch bolt is in the second position.

13. The smart lock of claim 10, wherein the latch bolt comprises a recess arranged to receive the actuator when the latch bolt is in the second position.

14. The smart lock of claim 10, wherein the latch bolt has a bolt throw of 14 millimetres to 20 millimetres.

15. The smart lock of claim 1, wherein the lock is a sash mortice lock and the lock mechanism is configured to be contained within the door and further comprises a deadbolt.

16. The smart lock of claim 15, wherein the locked position of the lock mechanism includes a first locked position where the latch bolt is configured in use to protrude from the door and a second locked position where the latch bolt and the deadbolt are configured in use to protrude from the door.

17. The smart lock of claim 16, wherein the lock mechanism is configured in use to be moveable in order from the second locked position, to the first locked position, to the unlocked position.

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